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ORIGINAL ARTICLE

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A supraomohyoidal plexus block designed to avoid complications

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Abstract Interscalene blocks of the brachial plexus are used for surgery of the shoulder and are frequently associated with complications such as temporary phrenic block, Horner syndrome or hematoma. To minimize the risk of these complications, we developed an approach that avoids medially directed needle advancement and favors spread to lateral regions only: the supraomohyoidal block. We tested this procedure in 11 cadavers fixed by Thiel's method. The insertion site is at the lateral margin of the sternocleidomastoid muscle at the level of the cricoid cartilage. The needle is inserted in the axis of the plexus with an angle of approximately 35° to the skin, and advanced in lateral and caudal direction. Distribution of solution was determined in ten cadavers after bilateral injection of colored solution (20 and 30 ml) and followed by dissection. In an eleventh cadaver, computerized tomography and 3D reconstruction after radio contrast injection was performed. In additional five cadavers we performed Winnie's technique with bilateral injection (20 and 30 ml).Concerning the supraomohyoidal block the injection mass reached the infraclavicular region surrounded all trunks of the brachial plexus in the supraclavicular region and the suprascapular nerve in all cases. The solution did not spread medially beyond the lateral margin of the anterior scalene muscle into the scalenovertebral triangle. Therefore, phrenic nerve, stellate ganglion, laryngeal nerve nor the vertebral artery were exposed to the injected solution. Distribution was comparable with the use of 20 and 30 ml of solution. Injections on five cadavers performing the interscalene block of Winnie resulted in an extended spread medially to the anterior scalene muscle.We conclude that our method may be a preferred approach due to its safety, because no structures out of interest were reached. Solution of 20 ml is suggested to be enough for a successful block.

Keywords Supraomohyoidal plexus block · Supraclavicular plexus blocks · Brachial plexus block · Anesthetic technique · Anesthesiology

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Introduction

Brachial plexus blocks may provide anesthesia for shoulder surgery as well as sustained postoperative analgesia. Several different approaches can be found in the literature: the interscalene block described by Winnie [24], its modification by Meier and Bauereis [12], Borgeat [3] and the supraclavicular approaches by Kulenkampff [9], Pham-Dang [15] and Moorthy [14]. Winnie's interscalene approach uses an insertion site at the level of the cricoid cartilage, from which the needle is advanced in a medial, dorsal and caudal direction perpendicular to the skin (Fig. 1). A safer approach would involve directing the needle insertion and anesthetic spread in a lateral direction. Meier has used this [12] by determining a very high insertion point 3 cm cranial to the cricoid cartilage (Fig. 1). Borgeat [3] located the insertion point at level of the cricoid, always orienting on the interscalene gap (Fig. 1). He placed the catheter with the "sandwich like" manner between the anterior and middle scalene muscle. Pham-Dang [15] located the insertion point of the needle more caudal, between the two heads of the sternocleidomastoid muscle with a lateral advancement deep to the clavicular insertion of latter muscle (Fig. 1). Performance of these blocks, however, may be accompanied by

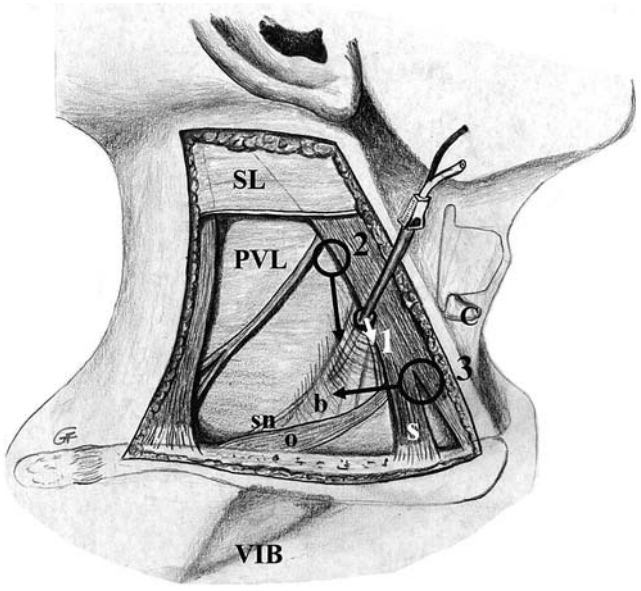

Fig. 1 Right lateral cervical region illustration showing the technique of the supraomohyoidal block in comparison to other existing techniques. *SL* superficial layer of the deep cervical fascia; *PVL* prevertebral layer of the deep cervical fascia; *s* sternocleidomastoid muscle; *o* omohyoid muscle; *b* brachial plexus, *sn* suprascapular nerve; *c* cricoid cartilage; *VIB* insertion site of the vertical infraclavicular block. *Circles* represent the insertion sites, *arrows* the direction of advancement. The drawn needle shows the technique of the supraomohyoidal block. The *white arrow* (*1*) represents Winnie's technique, *2* the technique of Meier, *3* the intersternocleidomastoid technique of Pham-Dang and *4* the technique of Borgeat

side effects such as temporary paresis of the phrenic [4, 5, 13, 15, 16, 22] or recurrent laryngeal nerves [4, 13, 15, 18, 23], Horner's syndrome [4, 7, 13, 15, 18, 23] and complications such as pneumothorax [23], hematoma [4], epidural [10], cases of spinal anesthesia [6], loss of function of cervical spinal cord [1], or injection into the vertebral artery [20]. It is desirable that a successful technique delivers anesthetic to all three trunks of the brachial plexus, which will form the fascicles in the infraclavicular region and consecutively the axillary nerve in the axillary region, and the suprascapular nerve. Additionally, it is undesirable to deliver local anesthetics to a zone medial to the lateral margin of the anterior scalene muscle, which would expose the phrenic nerve, epidural space, vertebral artery, and stellate ganglion to the local anesthetic. Therefore we performed a supraomohyoidal plexus block with an insertion site at the same level as Winnie's interscalene block but with the needle advanced in a lateral and caudal direction.

The aim of our study was to investigate the distribution of the injectate of two different volumes, 20 and 30 ml, for purpose of possible reduction of the volume. The use of high volumes may increase the incidence of side effects, especially the paresis of the phrenic nerve [5, 22] or complications mentioned above. In addition we compared the distribution of solution of our new approach to Winnie's interscalene block. Therefore, we performed latter block on additional cadavers using the two chosen volumes. Our new approach was tested on 11 cadavers as an anatomical study. A clinical study is in progress.

Materials and methods

Injections were performed on 11 cadavers with no heed to sex and age under the approval of the Anatomic Gift Program of the University of Graz. Cadavers were fixed using Thiel's method [19], which preserves the flexibility of the cadaver tissues and causes no shrinkage. Fascial planes are preserved and spaces can be easily identified. Previous investigations with injections have produced comparable results as in living humans [21].

The head was turned to the opposite side. The operator stood on the opposite side to perform the block. The interscalene groove was identified by palpation and the needle insertion site was determined at level of the cricoid cartilage (Fig. 1) at the posterior border of the sternocleidomastoid muscle. In cases in which the external jugular vein crosses the lateral margin of the sternocleidomastoid muscle at the level of the cricoid cartilage, the insertion point was moved caudally. With a skin needle angle of approximately 35°, the needle was advanced towards a point midway between the suprasternal notch (jugular fossa) and the ventral process of the acromion (Fig. 1), which defines the location of the plexus when using a vertical infraclavicular block, VIB [8]. The needle was advanced until we perceived at least two resistances. The first was the superficial layer of the cervical fascia, while the second represented penetration of the prevertebral layer of the deep cervical fascia, which was clearly identified even in the cadavers. Solution was injected just deep to this second plane (Fig. 1). The tip of the needle was placed just cephalad or at level of the omohyoid muscle, which was easily identified in the cadavers. The distance from the skin to this point was not more than 2.5 cm, depending on the cadaver's shape.

For each injection, we used a needle designed for atraumatic peripheral nerve blockade (Stimuplex D 0.7×50 mm; Braun Melsungen AG, Melsungen, Germany). On the first five cadavers, 30 ml of blue colored paint mixed with water were injected on both sides representing injections of high volumes. Five additional cadavers were injected with 20 ml bilaterally representing low volumes. Distribution of the injected solution was determined by dissection and photography. In one additional cadaver, an undiluted computerized tomography (CT) contrast (Jopamiro®, Jopamidol, 300 mg/ml; GL Pharma, Vienna) was injected, 30 ml on one side and 20 ml on the other. Spread of the contrast was documented by CT scans (2 mm slices) followed by three-dimensional reconstruction (Virtuoso software, Siemens, Graz, Austria).

To compare to an established technique, we performed the interscalene block of Winnie [24] on additional five cadavers. After feeling two resistances, we injected 30 ml Jopamiro® on all right and 20 ml on all left sides. On one cadaver of this group, the contrast was colored blue. The dissemination was documented by CT scans (2 mm slices). The cadaver with colored contrast was dissected after CT investigation and the spread was recorded by photography.

Results

With injection of 30 ml of solution by our new technique, dye spread in the posterior triangle and reached the infraclavicular region in each case. All three trunks of the brachial plexus were surrounded in the supraclavicular region as well as infraclavicular. If the trunks already formed the fascicles, all three of them were surrounded. The suprascapular nerve was also stained in each case, even when it passed through the middle scalene muscle separately. We had no spread medial of the lateral margin of the anterior scalene muscle, ventral or dorsal of latter muscle. It did not reach the scalenovertebral triangle. Specifically, solution did not spread to the phrenic nerve, stellate ganglion, or the recurrent laryngeal nerve. Solution stayed deep to the prevertebral layer of the deep cervical fascia (Figs. 2, 3).

With injection of only 20 ml of solution, the dye was also evident only laterally. The same spread was documented as with the use of 30 ml. Specifically, injection fluid reached the infraclavicular region and surrounded all three trunks of the brachial plexus and the suprascapular nerve. The phrenic nerve was not stained. The fluid did not spread into the scalenovertebral triangle. In one case it reached the lateral border of the posterior interscalene gap (Fig. 4).

When examined by CT, 30 ml of injected solution was similarly seen to spread predominantly laterally. Confirming our dissection findings, solution always surrounded all three trunks of the brachial plexus including the suprascapular nerve. It also reached the infraclavicular region but did not disseminate medial to the lateral margin of the anterior scalene muscle (Fig. 5). Injection of 20 ml contrast-containing solution was seen to spread out far lateral and reached the area of the medial margin of the scapula, but stayed under the prevertebral layer (Fig. 6). There were no differences in the distribution of 20 and 30 ml volumes.

The group of interscalene blocks by the Winnie technique showed spread in a lateral direction in all cases. With the use of 30 ml, the dye additionally distributed medial of the anterior scalene in four of the five cases (Fig. 7). The solution disseminated ventral and dorsal of the anterior scalene muscle. It reached the phrenic nerve, the vagus nerve, the sympathetic trunk, and the great vessels of the superior mediastinum (Fig. 7). Medial spread was documented twice using 20 ml (Fig. 7). The dye reached the vagus and phrenic nerve.

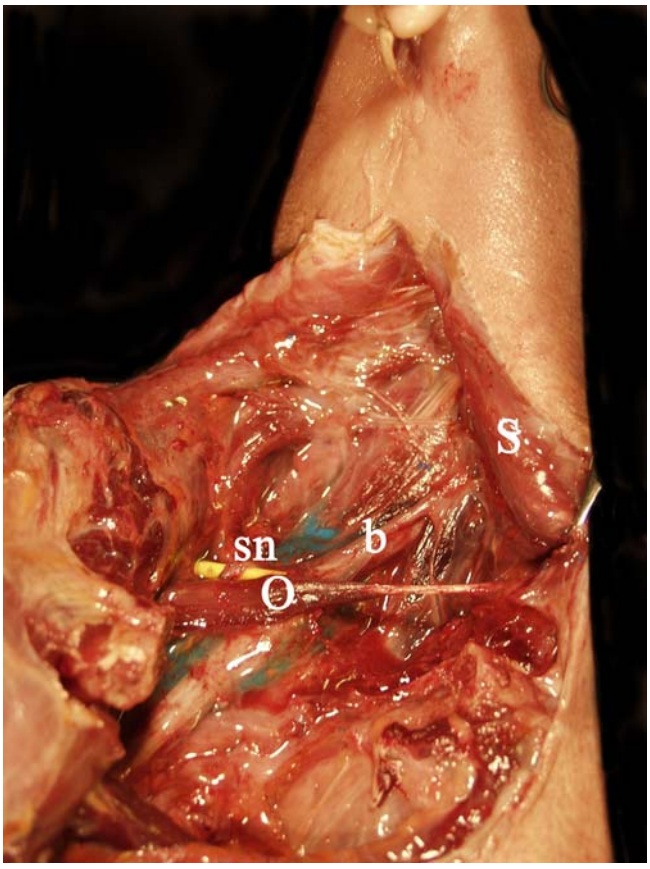

Fig. 2 Right lateral cervical region *s* sternocleidomastoid muscle: overview of the injected area after injection of 30 ml of *blue* colored injection mass. The clavicle has been removed. The *blue* injection mass is visible under the omohyoid muscle (*O*), surrounding the brachial plexus (*b*) and the suprascapular nerve (*sn*)

Discussion

The technique of the supraomohyoidal block presented in this study shows significant differences to other existing techniques. Winnie [24] determined the same insertion site but advanced the needle medially and dorsally into the interscalene gap. Meier [12] described an insertion point more cephalad, also orienting on the interscalene gap. In the latter technique the advanced needle reached the superior trunk of the brachial plexus as well as the lateral convex curve of the phrenic nerve on its way to the ventral face of the anterior scalene muscle. Although the second modified technique of Borgeat [3] seemed to be similar to our approach there are significant differences. Borgeat [3] oriented on the interscalene gap, placing the catheter between the anterior and middle scalene muscle. The needle direction had to be changed medially or laterally depending on the patient's shape whereas in our approach the needle is strictly oriented laterally. With the changing needle direction, Borgeat's approach still had a risk of medial spread with consecutive complications [4]. The intersternocleidomastoid technique of Pham-Dang [15] had

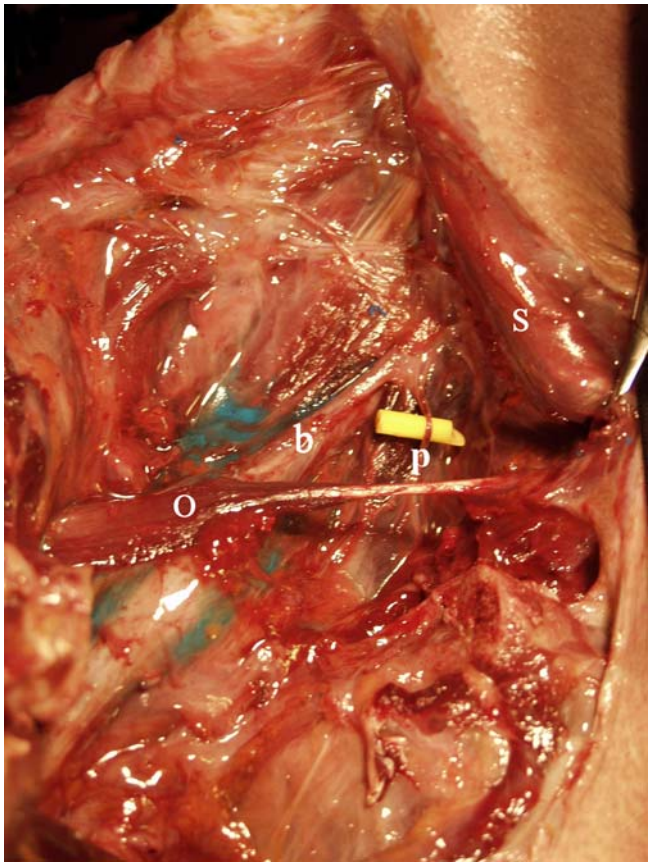

Fig. 3 Right lateral cervical region *s* sternocleidomastoid muscle: overview of the injected region. The clavicle is removed; the *blue* colored injection mass has not reached the phrenic nerve *p*, *yellow* bar is put underneath the nerve and ventral of the anterior scalene muscle

an insertion site more caudal to our approach and the needle was advanced far laterally. Its tip reached the trunks of the brachial plexus with an angle of about 30°–40°. Moorthy's [14] modified supraclavicular technique is not comparable with the techniques mentioned above. With this block the needle is advanced very distally in direction to the axillary fossa. The tip of the needle is located beyond the clavicle. Additionally, indications for this technique are mainly surgical procedures at the forearm whereas the other techniques can be used for shoulder surgery.

Common approaches for brachial plexus blockade, like the interscalene block [24] or its modification [3, 12] are associated with a variety of side effects and complications, systematically listed by Long et al. [11]. They are caused by spread of local anesthetics solution to structures medially to the lateral margin of the anterior scalene muscle and by advancement of the needle medially into vessels or lung. As a consequence, rare complications such as a permanent loss of cervical spinal cord [1], a total spinal anesthesia [6], or an epidural anesthesia [17] are reported. Vester-Andersen [23] reported as side effects an incidence of 75% of Horner's syndrome using Winnie's technique. Hempel [7] mentioned Horner's

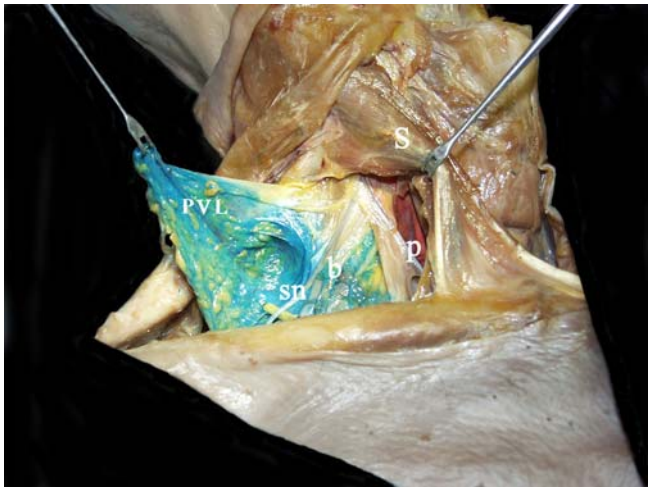

Fig. 4 Right lateral cervical region *s* sternocleidomastoid muscle: overview of the injected region, use of 20 ml of blue colored injection mass. The prevertebral layer of the deep cervical fascia (*PVL*) is lifted, the brachial plexus (*b*) and the suprascapular nerve (*sn*) are surrounded in the posterior triangle, and the phrenic nerve (*p*) is not reached

syndrome in one third of the cases with the same technique used. Meier and Bauereis [12] aimed to avoid a spread to this region by shifting the insertion site cephalad to the level of the superior margin of the thyroid cartilage, and also by aiming the needle laterally. However, they still reported 13% Horner's syndrome, 3.3% temporary block of the phrenic nerve, and hoarseness in 6.5% [13]. Using a lateral advancement

Fig. 5 CT-scan and 3D reconstruction of the *left* side of a cadaver injected with 20 ml of radio contrast. The injection mass (*asterisk*) is disseminating to the infraclavicular and lateral cervical region but not spreading out medial of the first rib (*fr*)

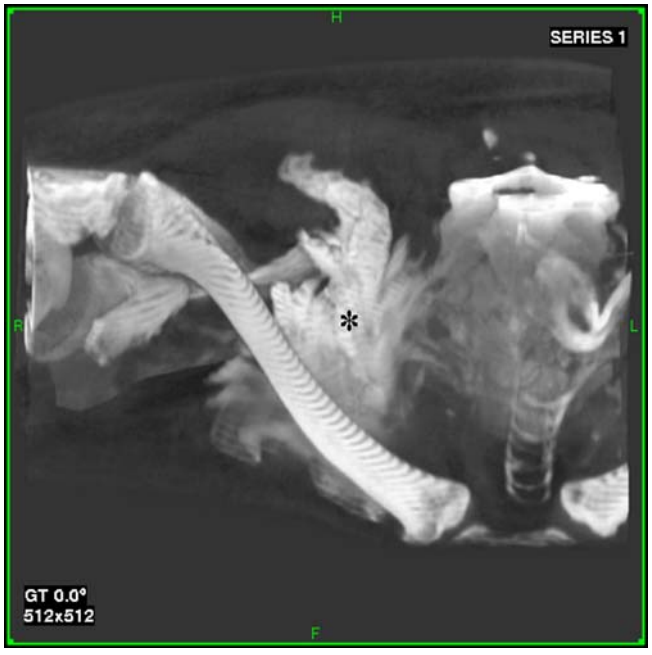

Fig. 6 CT-scan and 3D-reconstruction of the *right* side of the same cadaver as in Fig. 5, injected with 35 ml of radio contrast. Dissemination of the injection mass (*asterisk*) is comparable to the smaller volume shown in Fig. 4

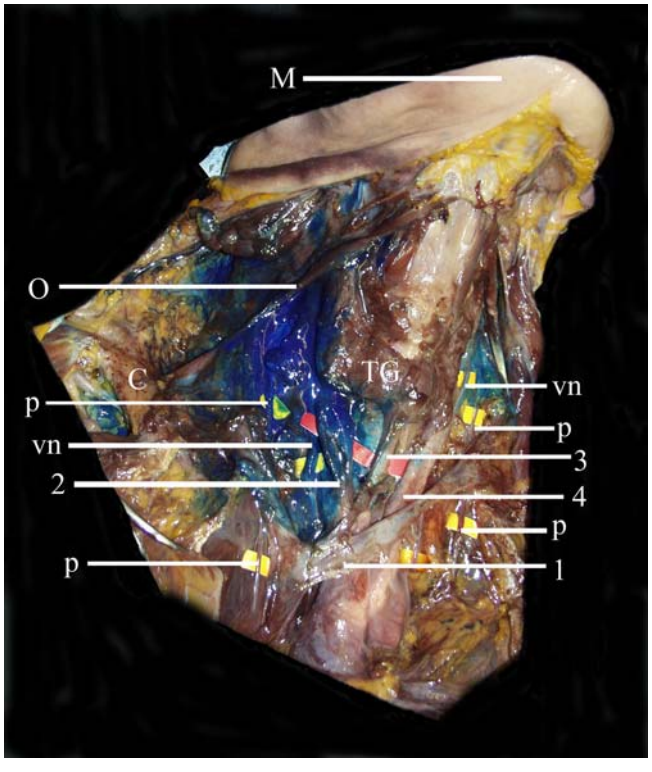

Fig. 7 Ventral view of the neck after injection of 30 ml on the *right* side and 20 ml on the *left* using Winnie technique of interscalene blockade. Anatomical landmarks are the left brachiocephalic vein (*1*), the mandible (*M*), the thyroid gland (*TG*), the clavicle (*c*), the omohyoid muscle (*o*), the brachiocephalic trunk (*2*, *red* labeled), the left common carotid artery (*3*, *red* labeled) and the left subclavian artery (*4*). The dye is surrounding the phrenic nerve (*p*, *yellow* labeled), the vagus nerve (*vn*, *yellow* labeled) on both sides

Pham Dang reported an unexpected high rate of asymptomatic phrenic nerve block of 60% [15]. In contrast even to the latter rate, Urmey [22], Casati [5] and Sala-Blanch [16] reported 100% of hemi diaphragmatic paresis after performing Winnie's interscalene block using different volumes between 20–52 ml. Other minor side effects were transient Horner's syndrome in 10% [15] and transient recurrent laryngeal nerve block in 0.5%. With our supraomohyoidal block, the insertion site is at the level of the cricoid cartilage like Winnie's block but the needle is directed laterally and distally. This change of direction towards the posterior cervical triangle evidently causes the needle to reach the plexus somewhat more distally and laterally to the techniques of Winnie, Meier and Borgeat. The change diminishes the risk of medial spread and avoids advancement towards the pleural cupola. Solution is reliably delivered to the suprascapular nerve. The tip of the needle reaches the lateral area of the well palpable part of the brachial plexus, which is very laterally of the interscalene gap and not deeper than 1.5 cm to the skin. Our observation corresponds to the observations of Bittar [2], who mentioned to reach the brachial plexus in a depth of 0.7–1.5 cm in an average adult, and in obese patients not more than 2.5 cm. Accordingly, structures medially of the anterior scalene muscle like the pleural cupola should be out of danger.

Concerning the volume, we have to mention certain points. With the use of 30 ml, no undesired nerve was reached. Injection of a volume of 20 ml delivered solution to all structures already mentioned may decrease the risk of systemic complications. According to Winnie's technique, we documented an unexpected and uncontrollable distribution medial to the anterior scalene muscle especially with the use of 30 ml. This may explain 100% incidence of paresis of the phrenic nerve as well as the case report of Dutton [6] who described a total spinal anesthesia after interscalene block with the use of 40 ml.

Conclusions

Anatomical investigation of the supraomohyoidal block shows a successful deliver of solution to the brachial plexus even when relatively low volume is used, and avoids exposure of other nerves to anesthesia. Main nerves for shoulder surgery, such as the suprascapular and axillary nerve are reached in all cases and medial spread of solution is avoided. These observations predict a low risk for complications or side effects involving the phrenic nerve, sympathetic trunk, epidural space, spinal cord, or vertebral artery. Keeping the proposed needle direction, lesion of the pleural cupola should be impossible. Concerning the volume, we suggest the use of 20 ml. The very good results of this anatomical study need to be tested by further clinical investigations to document efficiency of the supraomohyoidal approach. If proved it may be taken as one little step further to

optimize peripheral nerve blocks for the good of the patients.

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